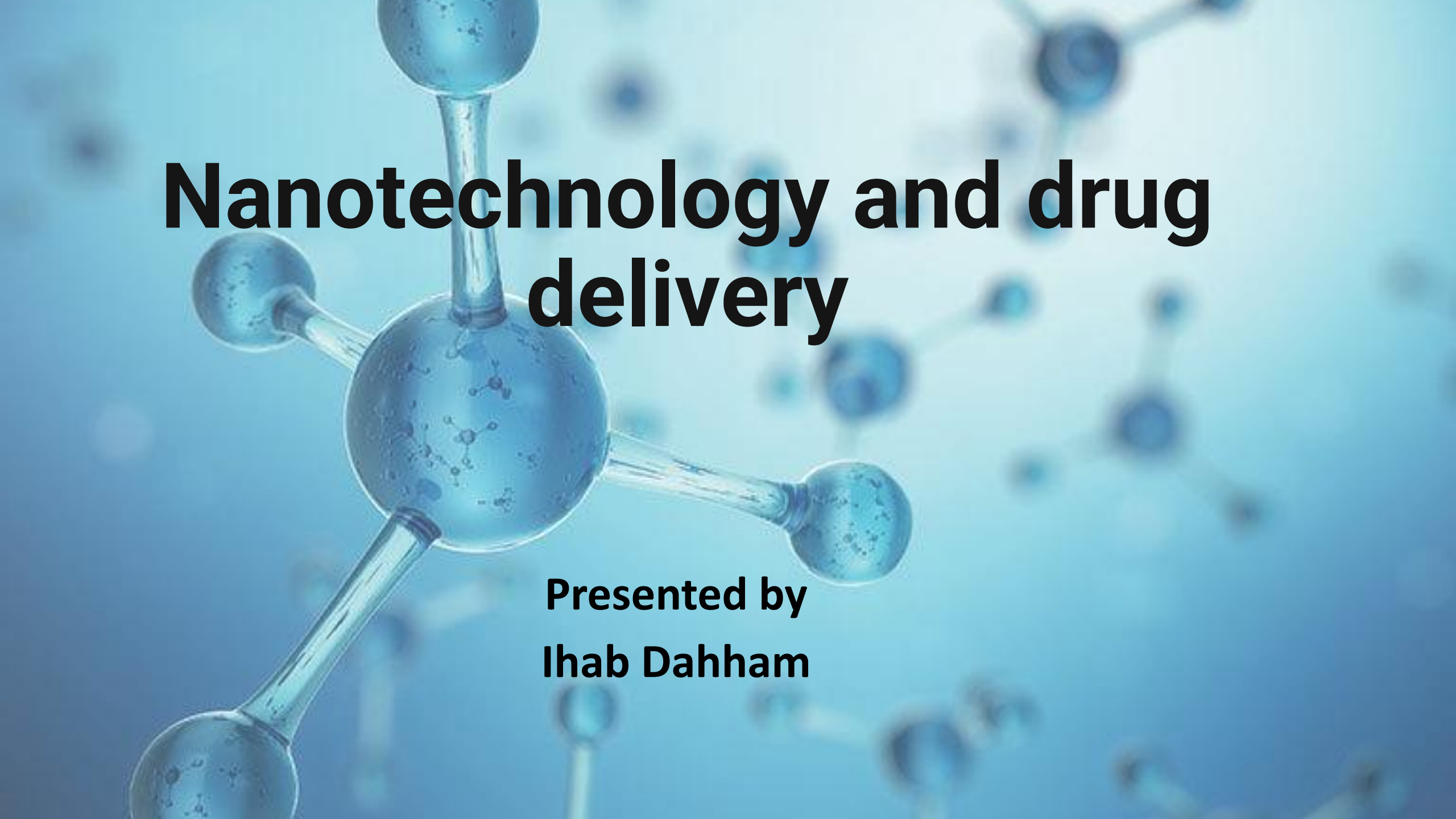


Nanotechnology and drug delivery

Presented by

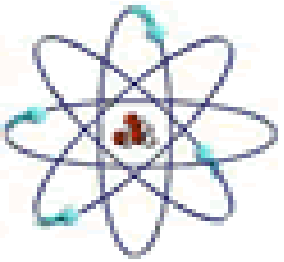
Ihab Dahham

INTRODUCTION:

- Drug delivery is transportation of a pharmaceutical compound in the body to safely achieve the desired effect via use of system or technology.
- It concerns with both quantity and duration of drug presence.

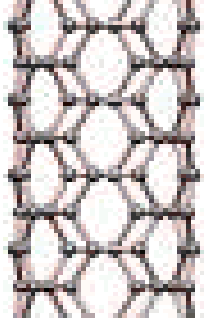
Nano-base drug delivery:

- Nanoparticles used as drug delivery vehicles are generally < 100 nm in at least one dimension, and consist of different biodegradable materials.
- Nanoparticles are taken up by cells more efficiently than larger micromolecules and therefore, could be used as effective transport and delivery systems.



atom

0.1 nm

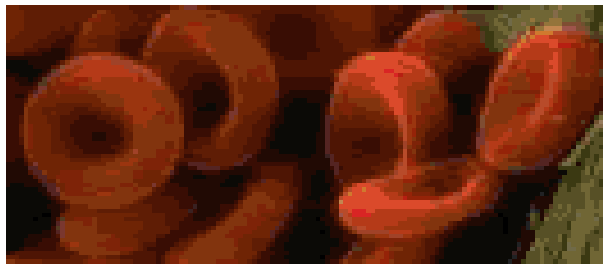


carbon nanotube diameter

5-10 nm

transistor

35 nm



red blood cell

10 μm

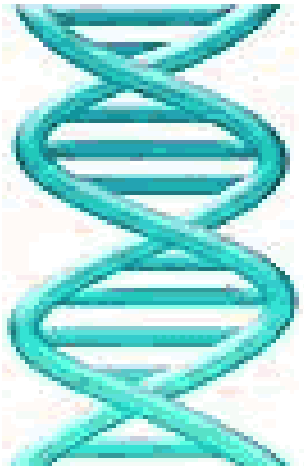
grain of sand

1 mm

10^{-1} 10^{0} 10^{1} 10^{2} 10^{3} 10^{4} 10^{5} 10^{6} nm

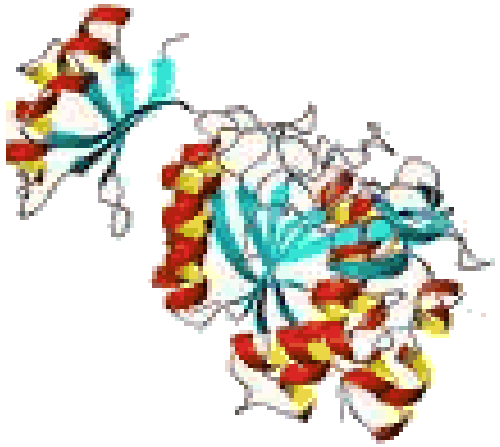
1 nm

DNA diameter



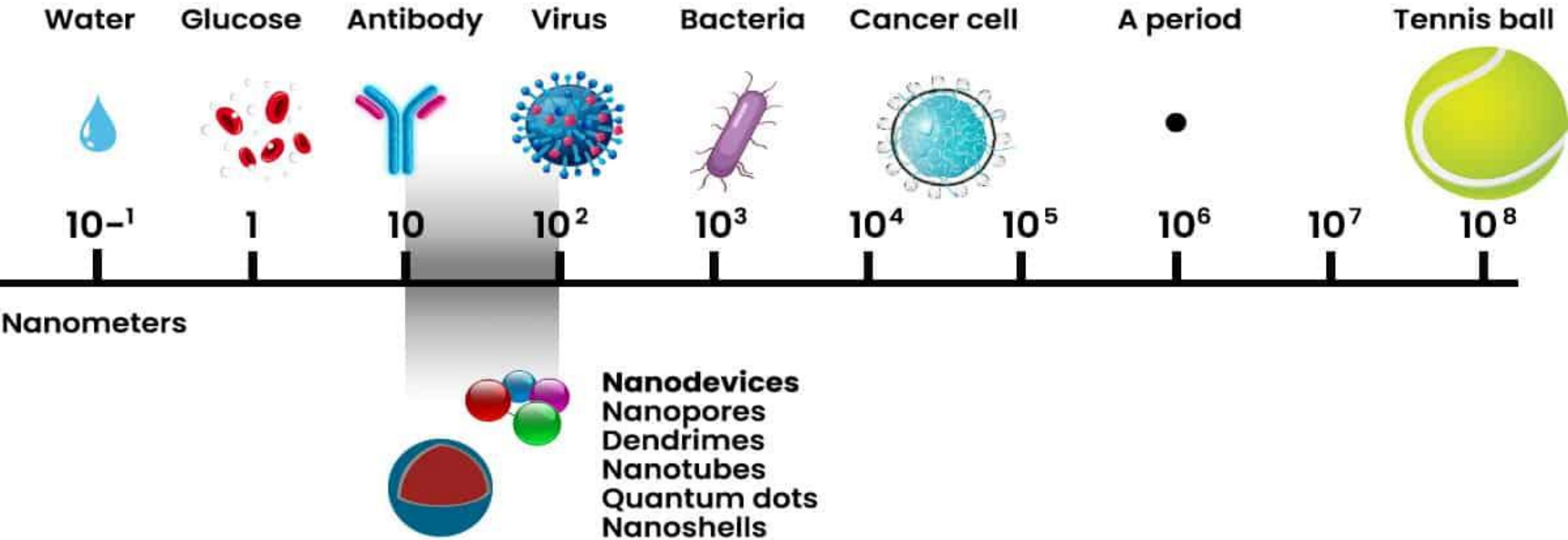
10 nm

protein



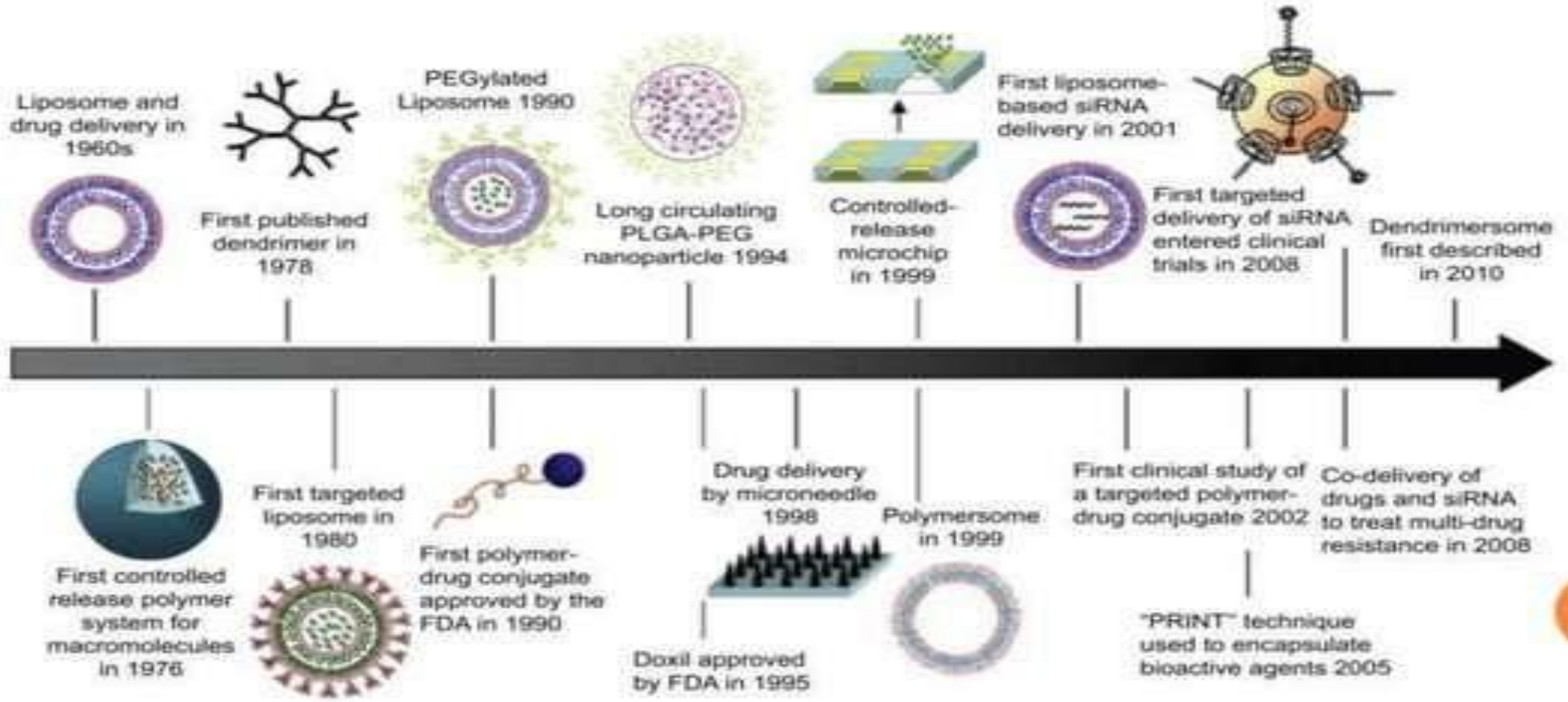
150 μm

human hair diameter


Water
Glucose
Antibody
Virus
Bacteria
Cancer cell
A period
Tennis ball
10−1
1
10
10 2
10 3
10 4
10 5
10 6
10 7
10 8
Nanometers
Nanodevices
Nanopores
Dendrimes
Nanotubes
Quantum dots
Nanoshells

TIMELINE:

- Nanotechnology and drug delivery timeline:

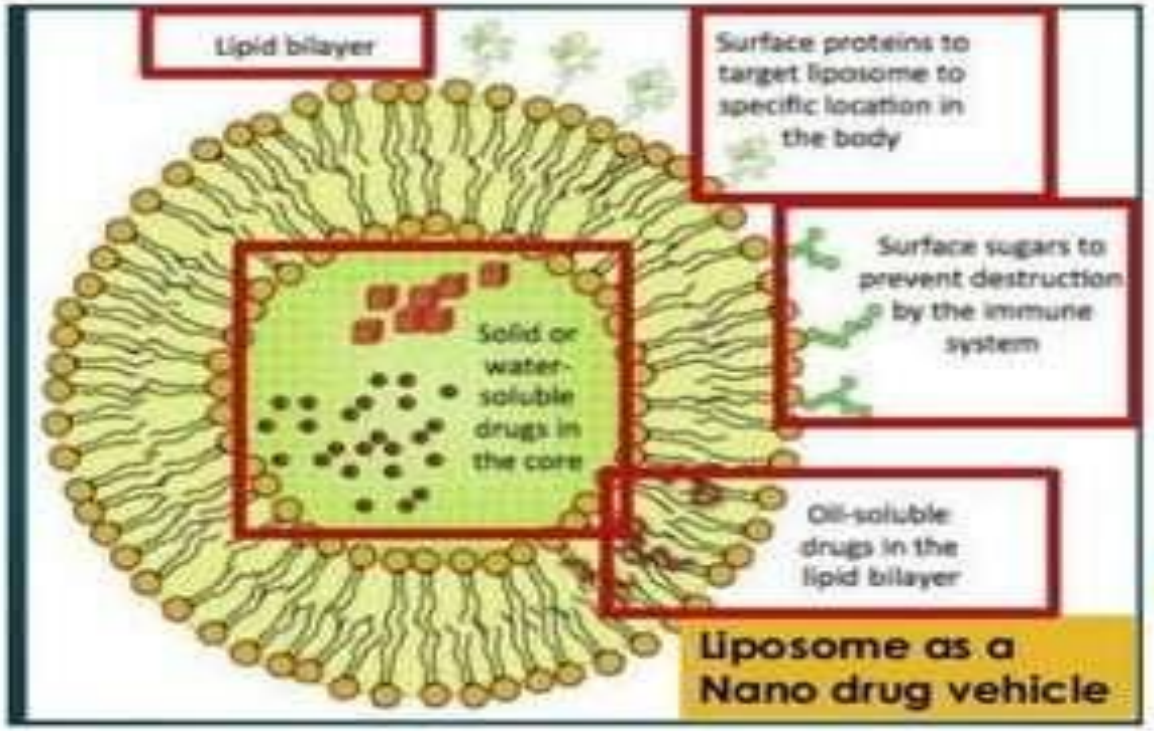


Why nano-particles?

Due to small size and large surface area and increase solubility and availability….	Can cross the blood brain barrier (BBB), enter the pulmonary system and be absorbed through the tight junctions of endothelial cells of the skin……	Similar size range as biological nanostructures and act as vehicles to carry drugs in different ways….

Liposome:

- ✓ Biocompatible…
- ✓ nanorugs are protected…
- ✓ Specifically target certain molecules…
- ✓ Nanodrug of different solubility are carried within liposomes.



2- Improved solubility:

- The poor solubility of drug is a major problem.
- improve solubility by delivering drug of small particle size allowing faster dissolution in blood stream leading to targeted drug delivery in a cell- or tissue- specific manner.
- Highly lipo-philic drugs can also be employed inside the hydrophobic core of biocompatible polymer or surfactant.

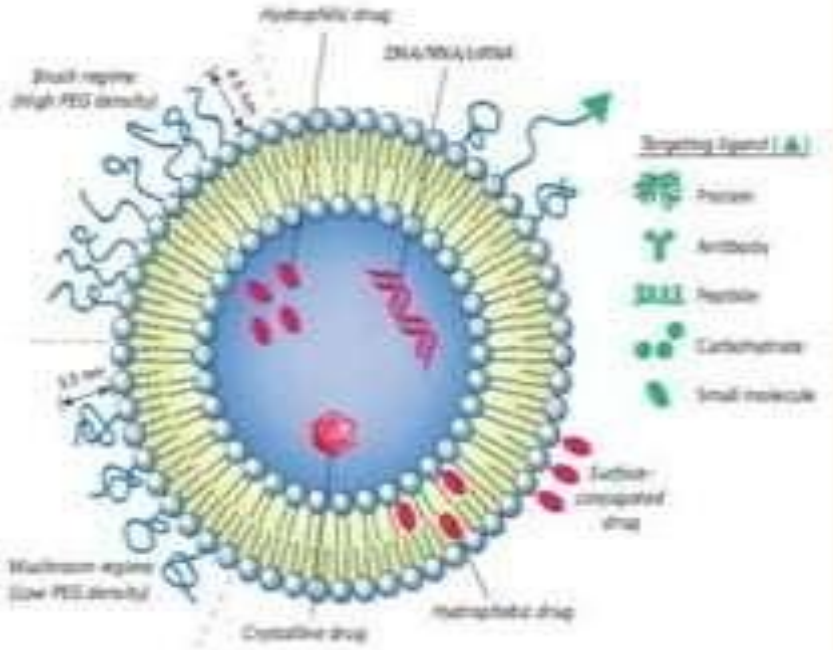
3- Stability:

Three main factors have been reported include bile salts, pH, pancreatic and gastric enzymes to destabilize oral delivery.

To protect the drug from these harsh condition drug is better coated with a biocompatible carrier.

Carrying payloads:

Nano-particles also aid in carrying large payloads, such as designing a delivery system containing multiple components as:



Combined therapeutic agents:

- Sometimes there is a need for combined formulations having more than one active ingredients for treatment of some diseases as tuberculosis.
- Multiple-block nano-particle formulations for example, liposome with its non-polar tails forming a hydrophobic core where the lipo-philic drug is entrapped and a hydrophilic drug can be attached to the surface.

COMPONENT OF DDS

Nano-Drug delivery system

Structure-Based

- Micro-needle arrays through skin painlessly
- Micro-needle patch for vaccine delivery

Electrically-Based

- Electrically controlled drug delivery nanocomposite composed of graphene oxide (GO) deposited inside a conducting polymer

Vehicle-Based

Nanosponges are a promising vehicle in treating cancer

- Releasing medication at the tumor site at a steady, controlled rate

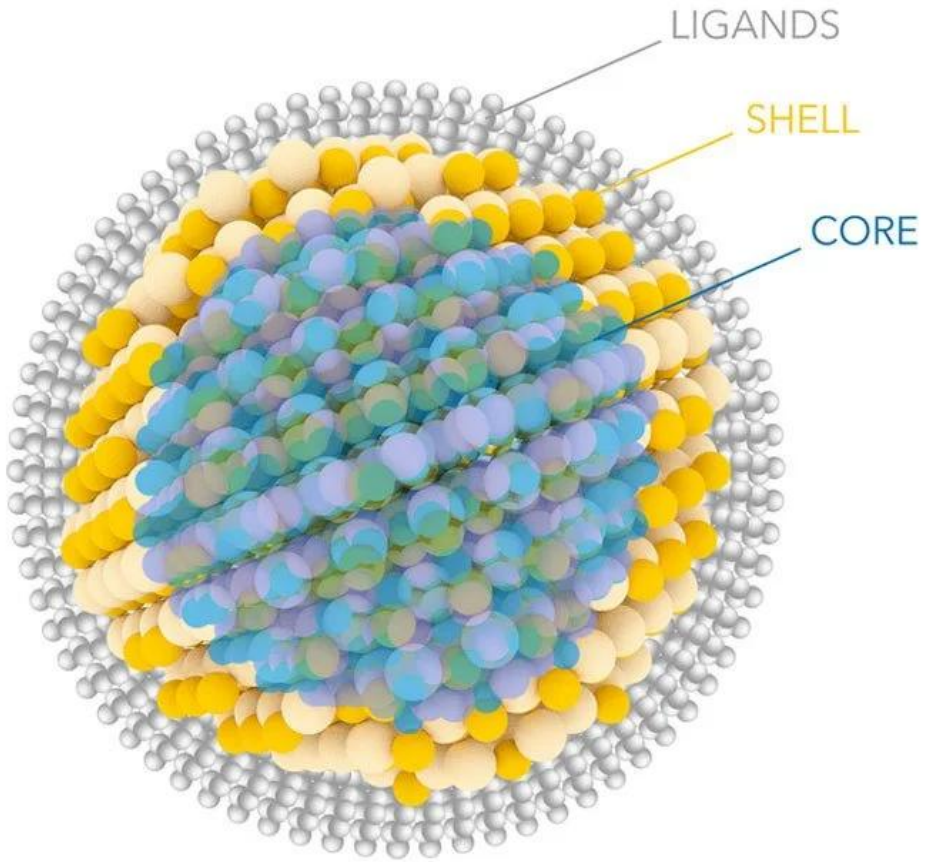
Nano vs. Traditional Drug delivery

Criteria	Traditional	Nano
Specificity	Drugs will pass through unaffected sites before reaching affected site	Delivered in more targeted manner to the affected site
Dosage Release	Higher initial dosage required No control ability	Able to control dosage by trigger, requirement, and even time release
Efficacy	Drug concentration in affected site is low	Drug concentration in affected site is more optimized
Side Effects	Inevitable exposure of unaffected sites to drugs	Lesser exposure of unaffected sites to drugs

Challenges involved

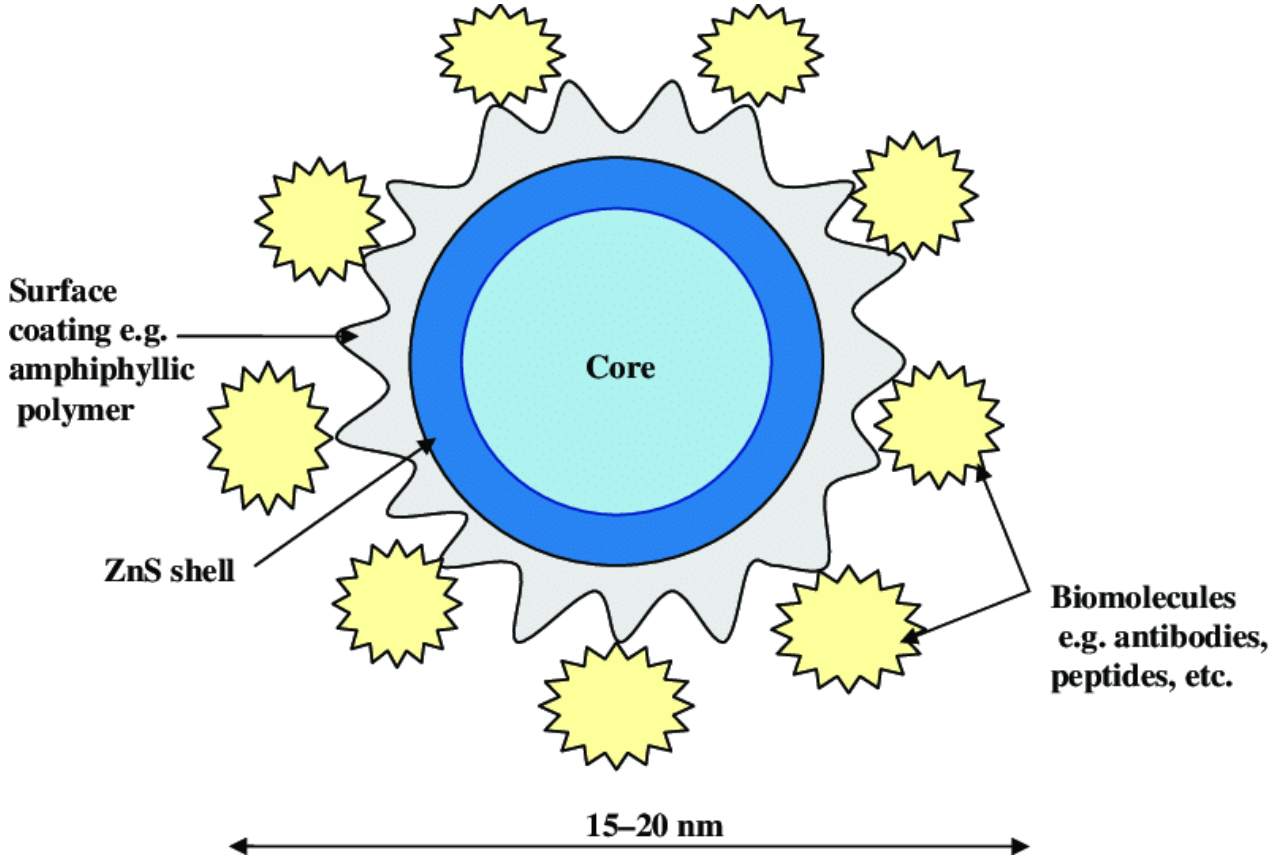
Quantum Dots: nanotechnology application

Quantum dots (QDs) are semiconductor nanocrystals that have unique optical and electronic properties due to their nanoscale size (typically 15-20 nm). Their tunable fluorescence, high photostability, and large surface area make them promising tools in **drug delivery**, especially for **targeted and image-guided therapies**.



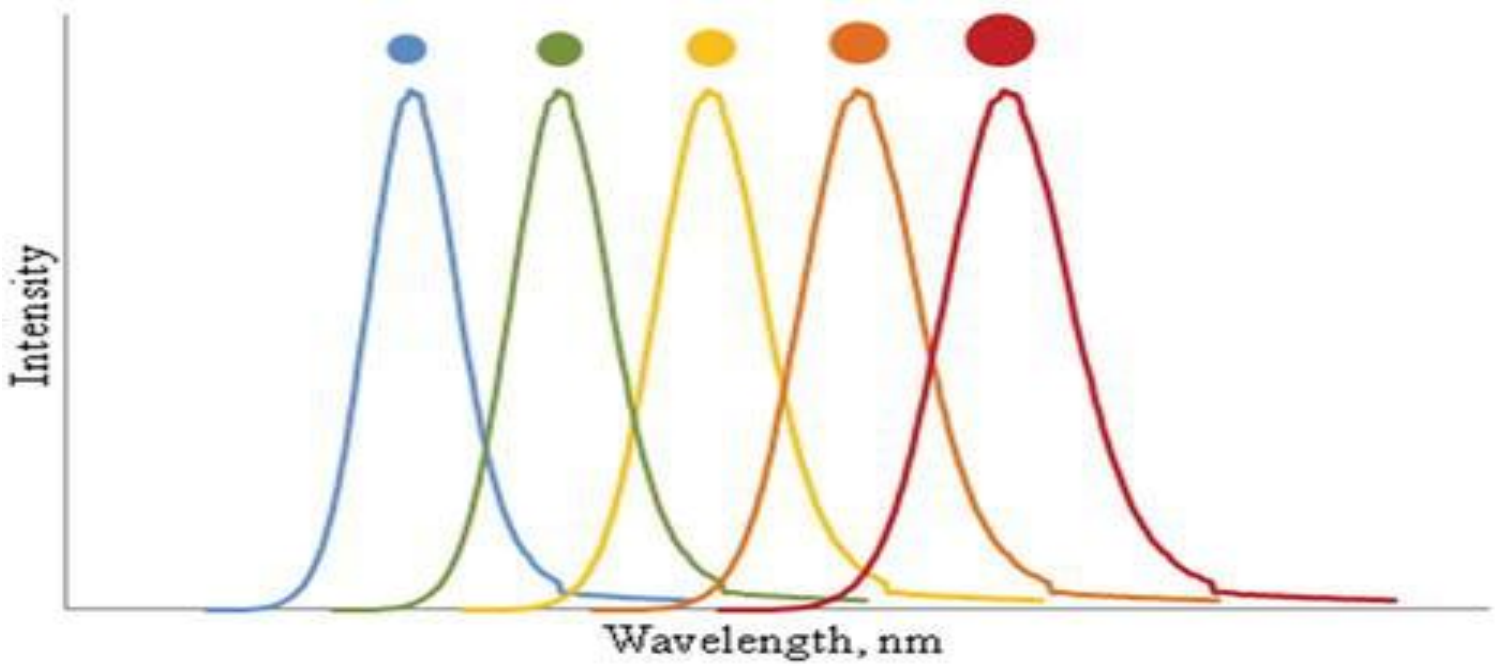
1. What Are Quantum Dots?

Quantum dots are nanocrystals made from elements like **cadmium selenide (CdSe)**, **cadmium telluride (CdTe)**, **indium phosphide (InP)**, and others. They are often coated with materials like **zinc sulfide (ZnS)** to enhance stability and reduce toxicity.



QDs properties:

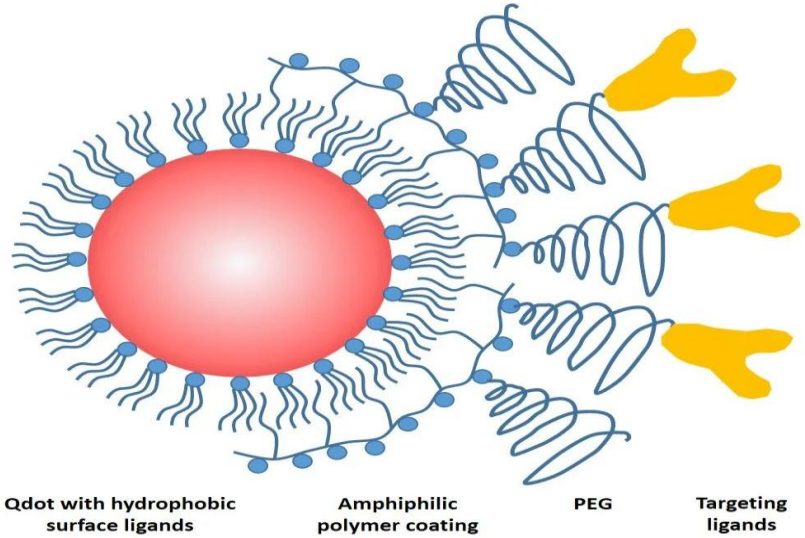
- **Size-dependent emission**: QDs fluoresce at specific wavelengths depending on their size.
- **High brightness and stability**: Ideal for long-term imaging.
- **Surface modifiability**: Their surfaces can be functionalized for bioconjugation.



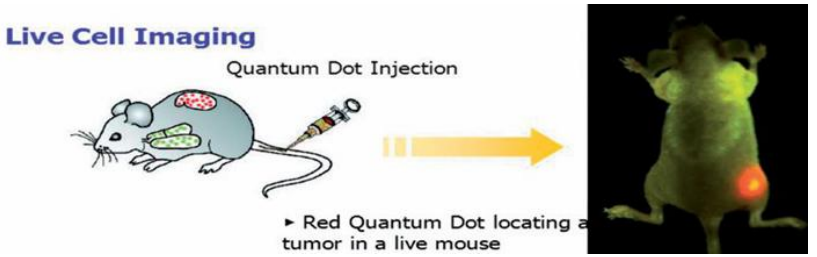
🔷 2. Why Use QDs in Drug Delivery?

✅ Unique Advantages

- **Multifunctionality**: Can carry drugs and act as imaging agents (theranostics).



- **Targeting**: Surfaces can be modified with ligands (antibodies, peptides) for cell-specific delivery.



- **Tracking**: Intrinsic fluorescence allows real-time tracking of delivery and drug release.
- **Controlled release**: Surface chemistry can be engineered for stimuli-responsive release (pH, temperature, light).

🔷 3. Mechanisms of Drug Delivery Using QDs

A. Passive Targeting

- Leverages the **enhanced permeability and retention (EPR)** effect in tumors.
- QDs accumulate in tumor tissue due to leaky vasculature and poor lymphatic drainage.

B. Active Targeting

- Surface conjugation with **targeting ligands**:
  - Antibodies (e.g., anti-HER2 for breast cancer)
  - Peptides (e.g., RGD for integrin targeting)
  - Aptamers

C. Stimuli-Responsive Delivery

- **pH-sensitive** coatings (for tumor or endosomal release)
- **Photo-triggered** release (using light to activate drug release)
- **Redox-sensitive** linkers (responding to glutathione levels inside cells)

4. Types of QD-Based Drug Delivery Systems

1) QD-Drug Conjugates

Drugs are **covalently bound or adsorbed** onto QDs. The system can be tuned for release inside target cells.

2) QD-Encapsulated Carriers

QDs are incorporated into larger carriers (liposomes, micelles, dendrimers) along with drugs. These provide: enhanced stability, reduced toxicity of QDs and co-delivery of multiple drugs

3) QD-Based Theranostic Platforms: QDs simultaneously

- **Track** drug delivery through fluorescence imaging
- **Deliver** therapeutic agents
- Can even assist in **photodynamic therapy (PDT)** or **photothermal therapy (PTT)**

🔷 5. Applications of QDs

🧠 Neurological Disorders

- Targeted delivery across the **blood-brain barrier (BBB)** using surface-modified QDs.
- Real-time tracking of drug penetration in the brain.

🎯 Cancer Therapy

- Tumor-specific targeting (e.g., folate-QD conjugates for ovarian cancer)
- Image-guided resection during surgery
- Monitoring of therapy response

🦠 Antimicrobial Delivery

- QDs functionalized with antibiotics to target drug-resistant bacteria.

🔷 6. Toxicity and Safety Concerns

⚠️ Main Challenges:

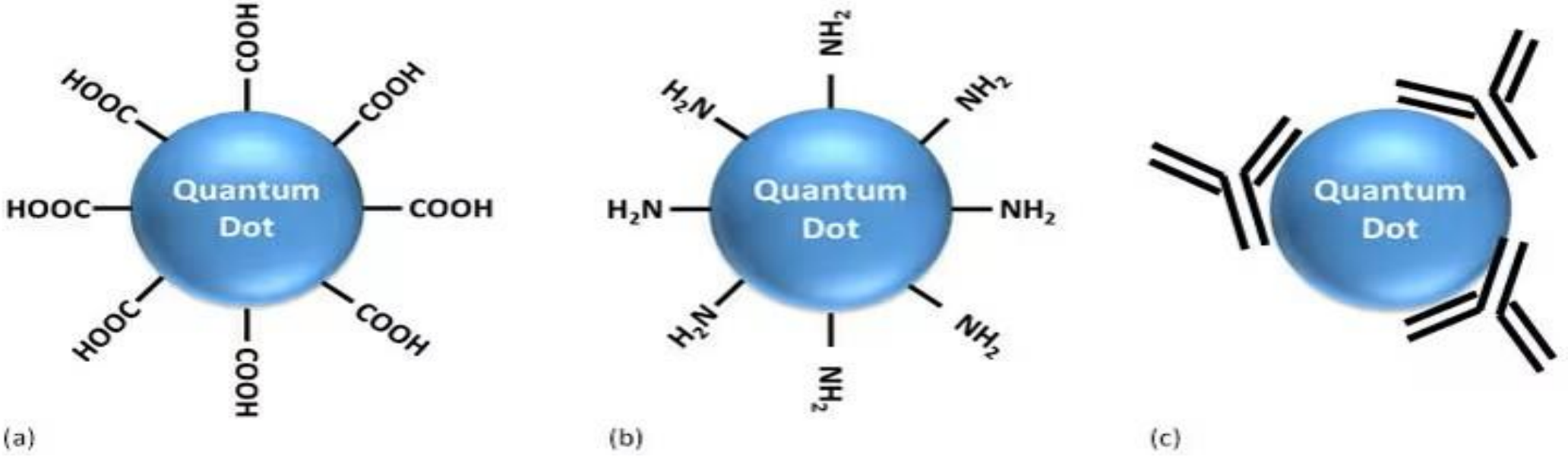
- **Heavy metal core** (like cadmium) can be toxic if QDs degrade.
- **Long-term accumulation** in organs (e.g., liver, spleen)
- **Oxidative stress** and inflammatory responses

Solutions:

- Use of **non-toxic QDs** (carbon dots, silicon QDs, InP QDs)
- **Biodegradable coatings** (PEG, chitosan, silica)
- **Encapsulation** in safer nanocarriers

7. Current Research

- **Green synthesis** of QDs using plant extracts or biomolecules
- **Carbon quantum dots (CQDs)**: low toxicity and good biocompatibility
- **Multimodal systems**: Combining QDs with MRI, PET, or CT agents
- **Personalized medicine**: QDs for patient-specific diagnostics and drug delivery




Thank you
for your attention